The H-R Diagram

# http://cass.ucsd.edu/public/tutorial/images/hr_local.gif

# Objective

The purpose of this lab is to give you a hands on experience with the Hertzprung-Russell, or H-R diagram. A simple review of its characteristics will be given. A basic knowledge of Microsoft Excel is helpful.

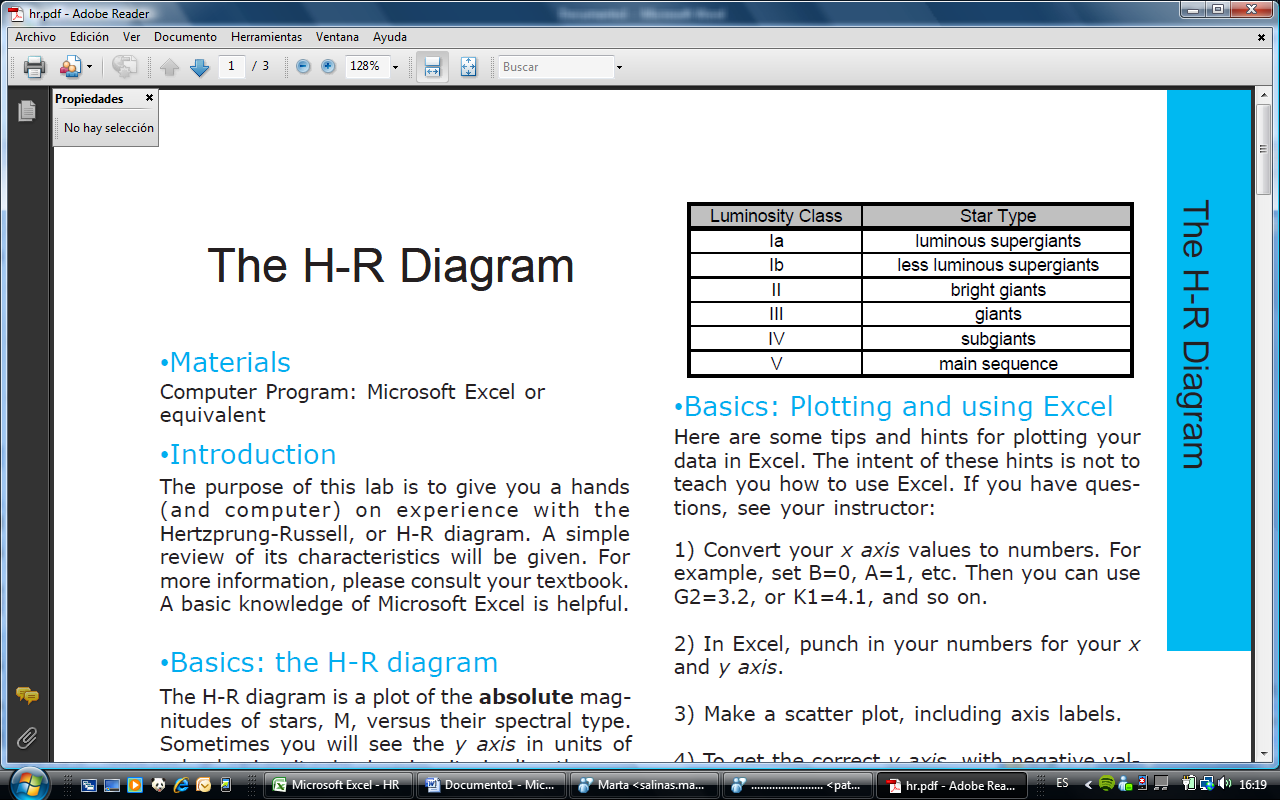
# Theoretical fundaments

The H-R diagram is a plot of the absolute magnitudes of stars, M, versus their spectral type. Sometimes you will see the y axis in units of solar luminosity, Lo. Luminosity is directly proportional to absolute magnitude, and in this lab, we will use the absolute magnitudes of stars. Remember, the more negative an absolute magnitude, the brighter the star. We will also be using the apparent magnitude, m, of stars. The apparent magnitude refers to how bright a star appears to us on Earth.

The x axis, spectral type, is a measure of a star’s surface temperature. Astronomers label spectral type with integers and letters, ranging from M10 (cool, red), to O0 (hot, blue). Note that a M7 type star is cooler than a M0 star, and that the order of letters from cool to hot is: M, K, G, F, A, B, O. The Sun is a G2 star with surface temperature of about 5800 K.

## Basics: Luminosity classes

In addition to classifying stars into spectral types, we group them into luminosity classes. A star with the temperature 5800 K might be a very luminous star (one with a negative value of M), or a dim star (large, positive M). Astronomers give groups of stars with similar luminosities special names. For example, the brightest stars are called luminous supergiants and are labeled with the luminosity class Ia. The Sun is a main sequence star, class V. See the chart below for additional information.



# Method

## Basics: Plotting and using Excel

Here are some tips and hints for plotting your data in Excel. The intent of these hints is not to teach you how to use Excel. If you have questions, see your instructor:

1) Convert your x axis values to numbers. For example, set B=0, A=1, etc. Then you can use G2=3.2, or K1=4.1, and so on.

2) In Excel, punch in your numbers for your x and y axis.

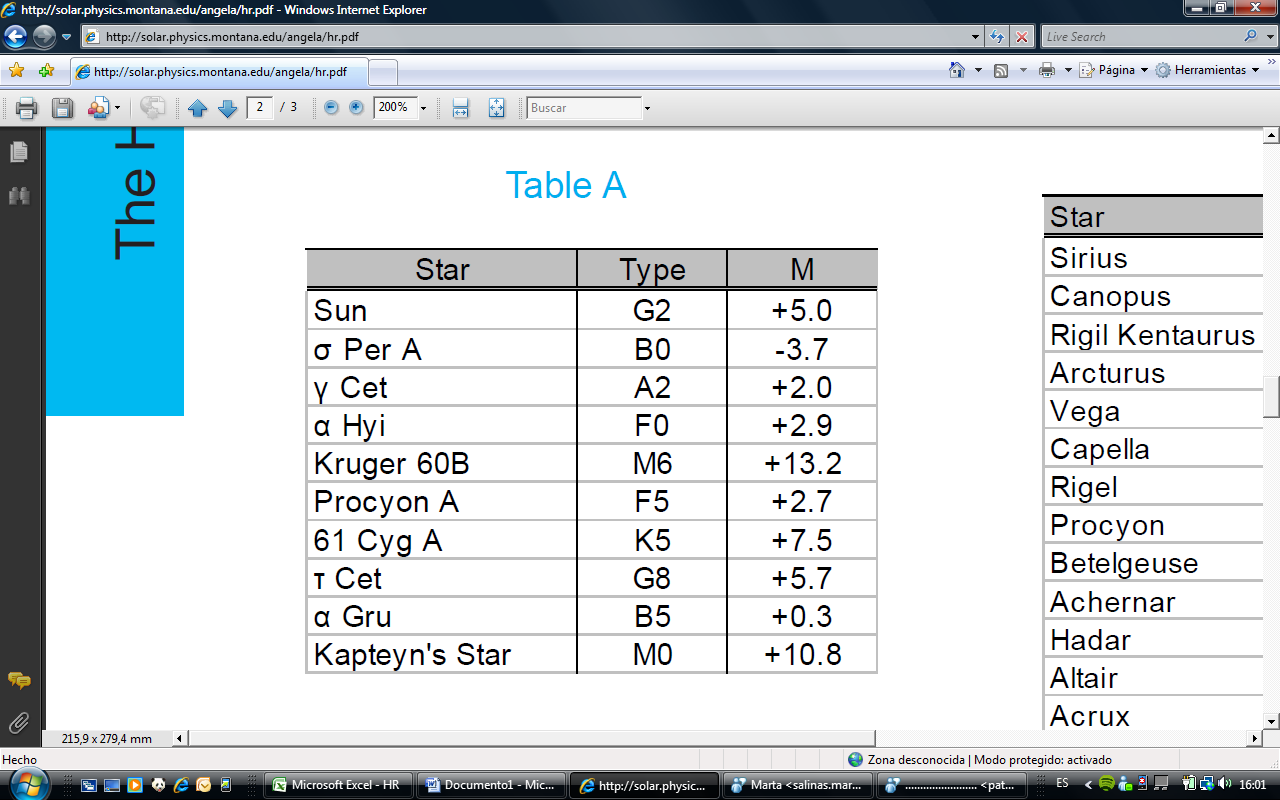
3) Make a scatter plot, including axis labels.

4) To get the correct y axis, with negative values at the top, click on the y axis in the plot you’ve already created. Go to “Format”, “Selected axis”, “Scale” tab. At the bottom, click “values in reverse order”

## Create your H-R diagrams

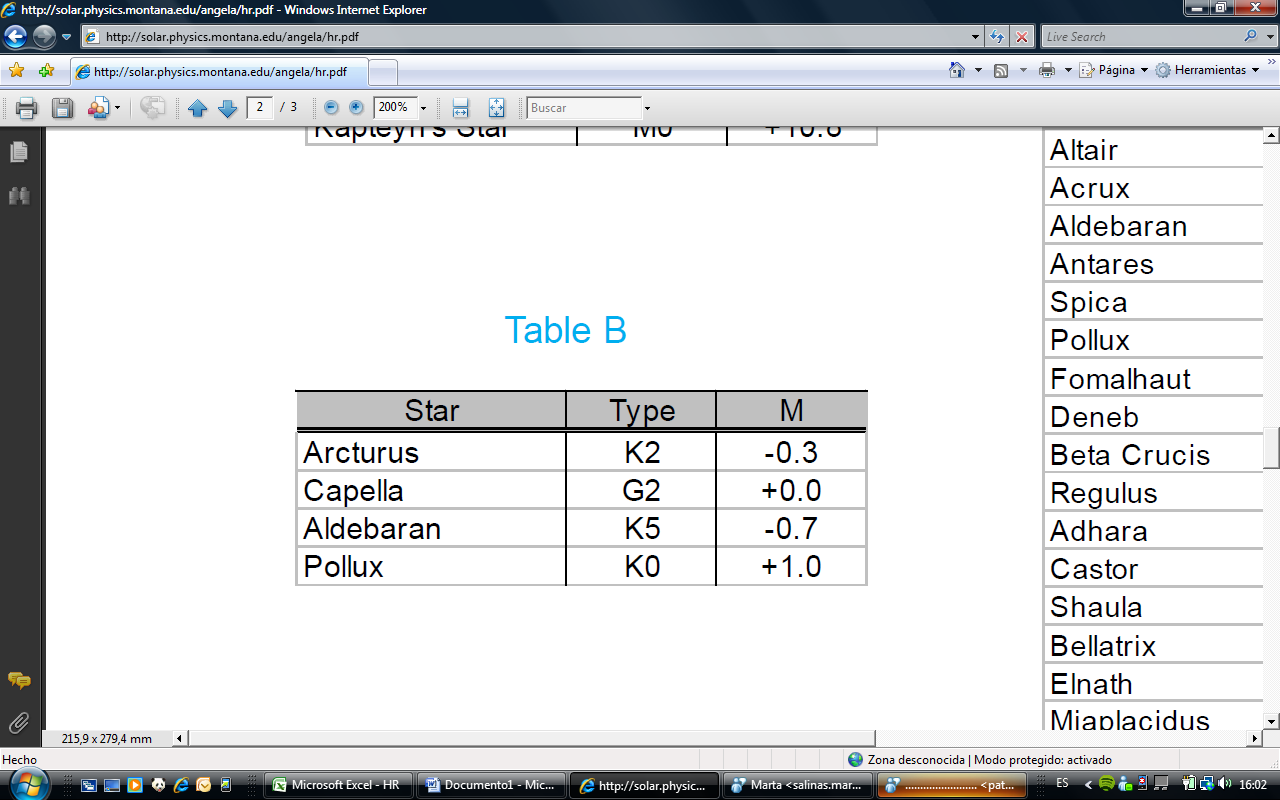
**A) Main Sequence Stars**

Plot, in Excel or another graphing program, the stars in Table A. The curve that approximately connects these points is the main sequence; most stars lie on this line. As mentioned earlier, the main sequence stars are luminosity class V stars. Make a label in your plot that indicates this fact.



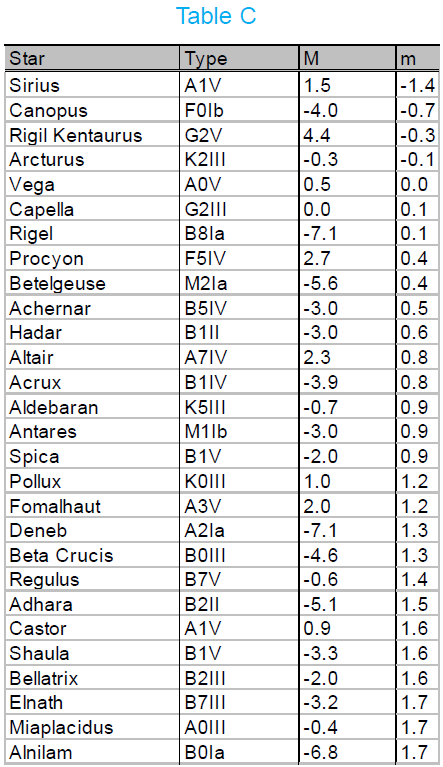
**B) Giant Stars**

Now plot the stars in Table B on the same diagram. These are giant stars, luminosity class III.



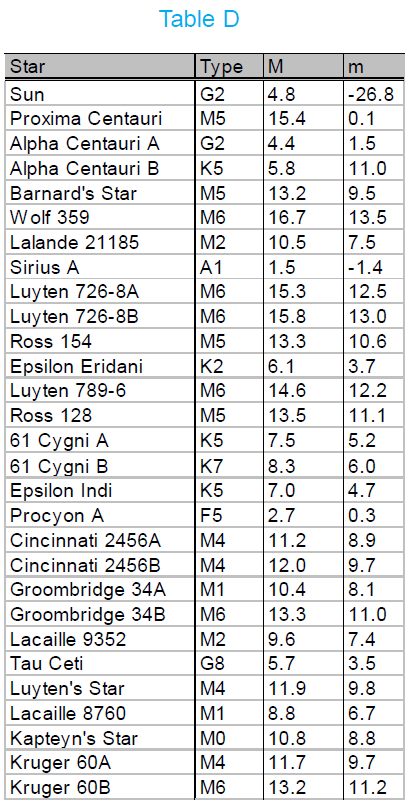
**C) The Brightest stars in the sky**

In a new diagram, plot all of the stars from Table A and Table C. In Table C, the roman numerals refer to the luminosity class, as in the table above. “M” is absolute magnitude, and “m” is apparent magnitude.



**D) The Nearest stars in the sky**

In another new diagram, plot all of the stars in Table D.



# Task

Make the H-R diagram of the stars on the last table. Represent the Magnitude in the y axis, and the surface temperature of the star in the x axis (you will need the relations given in the table attached).

What have you obtained?

# Conclusions

Answer these questions:

1. Why don’t the stars in Table B lie on the curve you created in part A) ?

2. How many magnitudes is Capella brighter than the Sun?

3. How many times brighter is Capella than the Sun?

4. Is Capella larger or smaller than the Sun?

5. What is the most common kind of bright (M) star (hot, cool, or spectral type)?

6. Estimate the average apparent magnitude, m, of the brightest stars (Table C).

7. When you look at a bright star in the sky, your probably looking at what speectral type of star?

8. What is the most common kind of star near the Sun?

9. Estimate the average apparent magnitude of the close stars (Table D).

10. We believe the stars near the sun are ordinary, common stars. Why don’t we see mostly common stars?

11. What would our night sky look like if all the stars in the galaxy had the same absolute magnitude as the Sun?

12. Write a short summary of what you learned.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Star** | **Name** | **Magnitude** | **Spectral Type** | **Surface Temperature** |
| alpha Cma | Sirius | -1,46 | A1 |  |
| alpha Car | Canopus | -0,72 | F0 |  |
| alpha Cen | Rigil Kent | -0,01 | G2 |  |
| alpha Boo | Arcturus | -0,04 | K1 |  |
| alpha Lyr | Vega | 0,03 | A0 |  |
| alpha Aur | Capella | 0,08 | G8 |  |
| beta Ori | Rigel | 0,12 | B8 |  |
| alpha Cmi | Procyon | 0,38 | F5 |  |
| alpha Eri | Archenar | 0,46 | B3 |  |
| alpha Ori | Betelgeuse | 0,50 | M2 |  |
| beta Cen | Hadar | 0,61 | B1 |  |
| alpha Aql | Altair | 0,77 | A7 |  |
| alpha Tau | Aldebaran | 0,85 | K5 |  |
| alpha Vir | Spica | 0,98 | B1 |  |
| alpha Sco | Antares | 0,96 | M1 |  |
| beta Gem | Pollux | 1,14 | K0 |  |
| alpha PsA | Fomalhaut | 1,16 | A3 |  |
| alpha Cyg | Deneb | 1,25 | A2 |  |
| beta Cru | Mimosa | 1,25 | B0 |  |
| alpha Leo | Regulus | 1,35 | B7 |  |
| epsilon Cma | Adhara | 1,50 | B2 |  |
| alpha Cru | Acrux | 1,58 | B1 |  |
| alpha Gem | Castor | 1,58 | A1 |  |
| gamma Cru | Gacrux | 1,63 | M3 |  |
| lambda Sco | Shaula | 1,63 | B1 |  |
| gamma Ori | Bellatrix | 1,64 | B2 |  |
| beta Tau | El Nath | 1,65 | B7 |  |
| beta Car | Miaplacidus | 1,68 | A2 |  |
| epsilon Ori | Alnilam | 1,70 | B0 |  |
| alpha Gru | Al Na'ir | 1,74 | B7 |  |
| epsilon Uma | Alioth | 1,77 | A0 |  |
| gamma Vel | Regor | 1,78 | O7 |  |
| alpha Per | Algenib | 1,79 | F5 |  |
| alpha Uma | Dubhe | 1,79 | K0 |  |
| delta Cma | Al Wazor | 1,84 | F8 |  |
| epsilon Sgr | KausAustralis | 1,85 | B9 |  |
| epsilon Car | Avior | 1,86 | K0 |  |
| eta Uma | Alkaid | 1,86 | B3 |  |
| theta Sco | Sargas | 1,87 | F1 |  |
| beta Aur | Menkalinam | 1,90 | A2 |  |
| alpha Tra | Atria | 1,92 | K2 |  |
| Gamma Gem | Alhena | 1,93 | A0 |  |
| alpha Pav | Peacock | 1,94 | B2 |  |
| delta Vel | Koo She | 1,96 | A1 |  |
| beta Cma | Murzim | 1,98 | B1 |  |
| alpha Hya | Alphard | 1,98 | K3 |  |
| alpha Ari | Hamal | 2,00 | K2 |  |
| alpha Umi | Polaris | 2,02 | F7 |  |
| sigma Sgr | Nunki | 2,02 | B2 |  |
| beta Cet | Diphda | 2,04 | K0 |  |
| zeta1 Ori | Alnitak | 2,05 | O9 |  |
| alpha And | Sirrah | 2,06 | B8 |  |
| beta And | Mirach | 2,06 | M0 |  |
| gamma1And | Alamach | 2,06 | K3 |  |
| theta Cen | Menkent | 2,06 | K0 |  |
| kappa Ori | Saiph | 2,06 | B0 |  |
| alpha Oph | Ras Alhague | 2,08 | A5 |  |
| beta Umi | Kochab | 2,08 | K4 |  |
| beta Gru | Al Dhanab | 2,10 | M5 |  |
| beta Per | Algol | 2,12 | B8 |  |
| beta Leo | Denebola | 2,14 | A3 |  |
| gamma Cen | Koo Low | 2,17 | A1 |  |
| gamma Cyg | Sadr | 2,20 | F8 |  |
| lambda Vel | Suhail | 2,21 | K4 |  |
| alpha Cas | Schedir | 2,23 | K0 |  |
| alpha Crb | Gemma | 2,23 | A0 |  |
| gamma Dra | Etamin | 2,23 | K5 |  |
| delta Ori | Mintaka | 2,23 | B0 |  |
| beta Cas | Caph | 2,25 | F2 |  |
| iota Car | Tureis | 2,25 | A8 |  |
| zeta Pup | Naos | 2,25 | O5 |  |
| zeta Uma | Mizar | 2,27 | A2 |  |
| epsilon Sco | Wei | 2,29 | K2 |  |
| alpha Lup |  | 2,30 | B1 |  |
| epsilon Cen |  | 2,30 | B1 |  |
| eta Cen |  | 2,31 | B1 |  |
| delta Sco | Dschubba | 2,32 | B0 |  |
| beta Uma | Merak | 2,37 | B0 |  |
| alpha Phe | Ankaa | 2,39 | K0 |  |
| epsilon Peg |  | 2,39 | K2 |  |
| kappa Sco |  | 2,41 | B1 |  |
| beta Peg | Scheat | 2,42 | M2 |  |
| alpha Cep | Alderamin | 2,44 | A7 |  |
| gamma Uma | Phecda | 2,44 | A0 |  |
| eta Cma | Aludra | 2,45 | B5 |  |
| epsilon Cyg |  | 2,46 | K0 |  |
| gamma Cas | Cih | 2,47 | B0 |  |
| alpha Peg | Markab | 2,49 | B9 |  |
| kappa Vel | Cih | 2,50 | B2 |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **TIPO O** | | **TIPO B** | | **TIPO A** | | **TIPO F** | | **TIPO G** | | **TIPO K** | | **TIPO M** | |
|  | T(ºK) |  | T(ºK) |  | T(ºK) |  | T(ºK) |  | T(ºK) |  | T(ºK) |  | T(ºK) |
| 0 | 50000 | 0 | 25000 | 0 | 11000 | 0 | 7500 | 0 | 6000 | 0 | 5000 | 0 | 3500 |
| 1 | 47000 | 1 | 23000 | 1 | 11000 | 1 | 7300 | 1 | 5900 | 1 | 4800 | 1 | 3200 |
| 2 | 44000 | 2 | 22000 | 2 | 10000 | 2 | 7200 | 2 | 5800 | 2 | 4700 | 2 | 3000 |
| 3 | 42000 | 3 | 20000 | 3 | 9800 | 3 | 7000 | 3 | 5700 | 3 | 4500 | 3 | 2800 |
| 4 | 39000 | 4 | 19000 | 4 | 9400 | 4 | 6800 | 4 | 5600 | 4 | 4300 | 4 | 2600 |
| 5 | 36000 | 5 | 17000 | 5 | 9000 | 5 | 6700 | 5 | 5400 | 5 | 4200 | 5 | 2400 |
| 6 | 33000 | 6 | 16000 | 6 | 8700 | 6 | 6500 | 6 | 5300 | 6 | 4000 | 6 | 2200 |
| 7 | 31000 | 7 | 14000 | 7 | 8300 | 7 | 6300 | 7 | 5200 | 7 | 3800 | 7 | 1900 |
| 8 | 28000 | 8 | 13000 | 8 | 7900 | 8 | 6200 | 8 | 5100 | 8 | 3700 | 8 | 1700 |
| 9 | 25000 | 9 | 11000 | 9 | 7500 | 9 | 6000 | 9 | 5000 | 9 | 3500 | 9 | 1500 |

Stellar Evolution

# Objective

Explain the stellar evolution to someone without a scientific formation

# Task

Your parents hear on TV that one day, the Sun will grow into a huge, red ball of gas extending all the way to Earth. They know you’re in an astronomy class and call you up to ask if this is true. Write a phone conversation you would have with them, explaining in laymen’s terms the birth and death of stars similar to the sun.

For extra credit, explain how larger and smaller stars’ evolution varies from the evolution of stars the size of the sun.

Alternative: If you like to draw, create an image for each step of the stellar evolution progress. Include a short statement of explanation with each drawing. A picture is worth a thousand words! The same extra credit applies, only with drawings and a short statement rather than in writing.